EP 13715 I (3)

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 418 055 A1**

(12) **EUROPEAN PATENT APPLICATION**

(21) Application number: 90309980.2

(51) Int. Cl.5: **H01T 13/39**, H01T 21/02

(22) Date of filing: 12.09.90

(30) Priority: 14.09.89 JP 236861/89

(43) Date of publication of application: 20.03.91 Bulletin 91/12

(84) Designated Contracting States: DE FR GB

(71) Applicant: NGK SPARK PLUG CO., LTD
14-ban, 18-gou Takatsuji-cho Mizuho-Ku
Nagoya-shi(JP)

(72) Inventor: Oshima, Takafumi
14-ban, 18-gou, Takatsuji-cho
Mizuho-ku, Nagaoya-shi(JP)

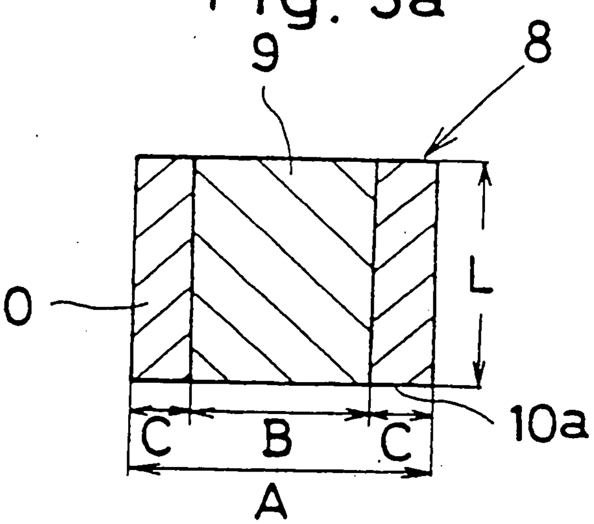
(74) Representative: Senior, Alan Murray et al
J.A. KEMP & CO 14 South Square Gray's Inn
London WC1R 5EU(GB)

# (54) Spark plug.

(57) In a spark plug for use in an internal combustion engine, a nickel-alloy based center electrode (7) is placed into a metallic shell (2) through a tubular insulator (3). An outer electrode (4) is depended from the metallic shell (2) to form a spark gap (6) with a front end (7a) of the center electrode (7). A spark portion (8) is secured to the center electrode (7), comprising a nickel-alloy based tubular clad tip (10) and an iridium or iridium-alloy based inner core (9) fit into the clad tip (10). A rear open end of the clad tip (10) is welded to a front end surface (7a) of the center electrode (7). A dimensional relationship among the center electrode (7), the inner core (9), and the clad tip (10) being determined as follows: $A \leqq 1.5$mm, $0.2\text{mm} \leqq B \leqq 0.8$mm, $C \geqq 0.1$mm, where A is an outer diameter of the front end surface (7a) to the center electrode (7), B is an outer diameter of the inner core (9), while C is the thickness of the tubular clad tip (10).



Fig. 3a




EP 0 418 055 A1

# SPARK PLUG

This invention relates to a spark plug for use in an internal combustion engine in particular to a separate sparking portion provided at a front end surface of a center electrode adjacent an outer electrode.

With a high output performance of an internal combustion engine, it has been required to ensure a positive ignition in air-fuel mixtures while at the same time, ensuring good spark-erosion resistance. In order to achieve this, iridium-alloy based or platinum-alloy based tips are welded to the front end surfaces of nickel-based center electrodes.

The tip allows positive ignition of the fuel-air mixture and exhibits good spark-erosion resistance. However, differential thermal expansion between the tip and the center electrode can cause thermal stress therebetween, causing the tip to fall off the center electrode leading to damage to a cylinder of the engine as the tip is alternatively exposed to a heated and cooled environment many times while the engine is running.

Therefore, it is an object of the invention to provide a spark plug for use in an internal combustion engine which may reduce the above drawbacks.

According to the invention, there is provided a spark plug for use in an internal combustion engine comprising:

a spark portion to be secured to an end surface of a center electrode, the spark portion comprising a nickel-alloy based tubular tip and an iridium or iridium-alloy based inner core mounted in the tip;

a dimensional relationship between the center electrode the inner core and the tip being as follows:

$A \leqq 1.5mm$, $0.2mm \leqq B \leqq 0.8mm$, $C \geqq 0.1mm$

where A is a diameter of the end surface of the center electrode, B is a diameter of the inner core, and C is the thickness of the tubular tip.

With the invention, the impact of thermal stress between the spark portion and the center electrode may be reduced thus preventing the spark portion from falling off the center electrode which otherwise would cause damage to a cylinder of the engine.

Advantageously the iridium-based alloy of the inner core comprises less than 70% by weight of an additive component and has a coefficient of linear thermal expansion in the range $7.0 \times 10^{-6}$ per °C 13 x $10^{-6}$ per °C and a melting point of more than 1900 degrees Celsius.

Further, at least one intermediate tubular layer may be provided between the tubular clad tip and the inner core, the intermediate tubular layer being made of metallic material, having a thickness of more than 50 $\mu m$, and a coefficient of linear thermal expansion which lies between that of the inner core and that of the tubular clad tip.

The intermediate tubular layer makes it possible to reduce thermal stress between the inner core and the clad tip when the spark portion is exposed to a high temperature environment.

Furthermore, the coefficient of linear thermal expansion of the intermediate tubular layer may be adapted to gradually increase in a direction from the inner core to the tubular clad tip.

The invention will be further understood from the following description, when taken together with the accompanying drawings which are given by way of example only and in which:

Fig. 1 is a plan view of a spark plug for use in an internal combustion engine according to a first embodiment of the invention, but partly sectioned;

Fig. 2 is a longitudinal cross sectional view of a spark portion around a center electrode according to a first embodiment of the invention, with the center electrode shown partly in section;

Fig. 3a is an enlarged longitudinal cross sectional view of the spark portion;

Fig. 3b is an enlarged upper plan view of the spark portion;

Fig. 4 is a view similar to Fig. 2 according to a first embodiment of the invention;

Fig. 5a is a view similar to Fig. 3a according to a second embodiment of the invention;

Fig. 5b is a view similar to Fig. 3 according to a second embodiment of the invention;

Fig. 6 is an enlarged upper view of a modified spark portion with an indication between coefficients of linear thermal expansion and diameters of intermediate layers.

Referring to Fig. 1 in which a first embodiment of the invention is shown numeral 1 designates a spark plug for use in an internal combustion engine. The spark plug 1 has a metallic shell 2 having a male thread portion 5 for a convenience when attaching to a cylinder head of the internal combustion engine. From a front end of the metallic shell 2, an outer electrode 4 is depended substantially in a manner of an arcuate configuration. Within the metallic shell, a tubular insulator 3 is concentrically placed into which a nickel-alloy based center electrode 7 is concentrically provided. A front end surface 7a of the center electrode 7 is located to be in registration with the outer electrode 4 to form a spark gap 6 therebetween. To the front end surface 7a of the center electrode 7, a spark portion 8 is secured which, as shown in Fig. 2, consists of a tubular clad tip 10 and an inner core 9 interfit into the clad tip 10 by means of cold ex-

trusion, for example.

It is appreciated that instead of the cold extrusion serration, roulette, shrinkage fit and press fit may be used.

In the meanwhile, an axial length (L) of the inner core 9 is determined to be generally equal to that of the clad tip 10 to make a front end of the core 9 in flush with that of the clad tip 10. The clad tip 10 is made of a nickel-based alloy which is the same material as the center electrode 7 is made. A rear open end 10a of the clad tip 10 is rigidly secured to the front end surface 7a of the center electrode 7 by means of an electrical welding as designated by a donation (We).

On the other hand the inner core 9 is made of iridium or iridium-based alloy such as 75wt% Ir - 25wt% Pt or 75wt% Ir - 25wt% Ni with Ir and Ni as an additive component. In this instance, linear thermal expansions of nickel, iridium and platinum-iridium based alloy is in turn $13.5 \times 10^{-5}$, $6.8 \times 10^{-5}$ and $9.3 \times 10^{-5}$ while the additive component is determined to include less than 70 wt%. Then, the inner core 9 is arranged to have a coefficient of a linear thermal expansion ranging from $7.0 \times 10^{-5}$ to $13.0 \times 10^{-5}$ with a melting point as 1900 degrees Celsius. As shown in Figs. 2a, 2b, a dimensional relationship among the center electrode 7, the inner core 9 and the clad tip 10 is determined as follows: $A \leqq 1.5$mm, $0.2\text{mm} \leqq B \leqq 0.8$mm, $C \geqq 1$mm, where a denotation (A) is an outer diameter of the front end surface 7a of the center electrode 7, a denotation (B) is an outer diameter of the inner core 9, while a denotation (C) is a thickness of the tubular clad tip 10.

In addtion to that the nickel-based clad tip 10 is welded to the nickel based center electrode 7, the dimensional determination among the center electrode 7, the inner core 9 and the clad tip 10 is such as to prevent the clad tip 10 from falling off the center electrode 7 with minimum stress between the clad tip 10 and the center electrode 7 when the spark portion 8 is exposed to a high temperature environment during running the engine for a long period of hours.

With the melting point of the iridium-based inner core 9 as more than 1900 degrees Celsius, it is possible to impart the inner core 9 of the spark portion 8 with a spark-corrosion resistant property even when the spark portion 8 is exposed to a high temperature environment due to a long mileage's running with a high revolution range.

A second embodiment of the invention is described hereinafter in reference to Fig. 4. In the second embodiment of the invention, like reference numerals identical to Fig. 3a are commonly used in Fig. 4. In this instance, a front portion of the clad tip 10 is cut by a length of (M), so that the front end of the inner core 9 can somewhat extend beyond that of the clad tip 10 to be exposed outside. The extended inner core 9 makes it possible to reduce an amount of a spark erosion of the spark portion 8 with a good performance of fuel ignition maintained. With the reduced amount of the spark erosion, the inner core 9 becomes acceptable as a product when the inner core 9 is as thin as 0.2 mm to 0.8 mm in diameter (B).

A third embodiment of the invention is described hereinafter in reference to Figs. 5a, 5b. In the third embodiment of the invention, like reference numerals identical to Figs. 3a, 3b are commonly used in Figs. 5a, 5b. In this instance, one piece of an intermediate tubular layer 11 is provided between the inner core 9 and the clad tip 10. The intermediate tubular layer 11 is made of an iridium-based alloy, a linear thermal expansion of which is predetermined to fall on between that of the inner core 9 and that of the clad tip 10. For this reason, the linear thermal expansion of the intermediate tubular layer 11 fall on $7.0 \times 10^{-5}$ at minimum, and $13.0 \times 10^{-5}$ at maximum.

The intermediate tubular layer 11 makes it possible to effectively reduce a thermal stress between the inner core 9 and of the clad tip 10 when the spark portion 8 is exposed to a high temperature environment due to a long period of running hours with a high revolution range.

Fig. 6 is a modified form of the third embodiment of the invention in which two pieces of intermediate tubular layers. Another intermediate tubular layer 11a is provided between the intermediate tubular layer 11 and the clad tip 10. A linear thermal expansion of the intermediate tubular layer 11a is predetermined to be greater than that of the intermediate tubular layer 11, but smaller than that of the clad tip 10. It is noted that the intermediate tubular layer may be made of Pt-Ir alloy, Pt-Ni alloy or Ir-Ni alloy.

In this instance, as shown in Fig. 6, thicknesses of the intermediate tubular layers 11, 11a are determined to be 100 µm each as corresponding to a distance between points P (Q) and Q (R) with points between (R) and (S) as a dimension (C) as a thickness of the clad tip 10.

When more than two pieces of intermediate tubular layers are provided, it is arranged that a linear thermal expansion of the intermediate tubular layer falls on between that of the inner core 9 and that of the clad tip 10, and gradually increases as approaching from the inner core 9 toward the clad tip 10.

As understood from the foregoing description, the spark portion 8 consists of the tubular clad tip 10 and the inner core 9 interfit into the clad tip 10, and the tip 10 is welded to the center electrode 7. As a result, metals of the same nickel-based alloy is mutually welded when the clad tip 10 is secured

to the center electrode 7. Thus leads to ensuring sufficiently enough securement between the clad tip 10 and center electrode 7 to prevent the clad tip 10 from falling off the center electrode 7 when the spark portion is exposed to a high temperature environment.

The intermediate tubular layer makes it possible to serve as a thermal stress relief member between the inner core 9 and the clad tip 10 when the spark portion is exposed to a high temperature environment. Therefore, even if a thermal stress is set up due to a difference of the thermal expansion between the inner core 9 and the clad tip 10, the thermal strees is effectively reduced to prevent the spark portion 8 from falling off the center electrode 7 so as to sufficiently protect the cylinder against a damage.

Further, with the melting point of the iridium-based inner core 9 as more than 1900 degrees Celsius, it is, of course, possible to impart the inner core 9 with a spark-corosion resistant property even when the spark portion 8 is exposed to a high temperature environment due to a long mileage's running with a high revolution range.

As many widely different embodiments of the present invention may be made without departing from the spirit and scope thereof, it is to be understood that the present invention is not limited to the specific embodiments, except as defined in the appended claims.

## Claims

1. A spark plug for use in an internal combustion engine comprising:
a spark portion (8) to be secured to an end surface (7a) of a center electrode (7), the spark portion (8) comprising a nickel-alloy based tubular tip (10) and an iridium or iridium-alloy based inner core (9) mounted in the tip (10);
a dimensional relationship between the center electrode (7) the inner core (9) and the tip (10) being as follows:
$A \leqq 1.5mm$, $0.2mm \leqq B \leqq 0.8mm$, $C \geqq 0.1mm$
where A is a diameter of the end surface (7a) of the center electrode (7), B is a diameter of the inner core (9), and C is the thickness of the tubular tip (10).

2. A spark plug according to claim 1, wherein the inner core 9 comprises an iridium-based alloy including an additive component of less than 70% by weight, and has a coefficient of linear thermal expansion in the range $7.0 \times 10^{-6}$ to $13.0 \times 10^{-6}$ per °C with a melting point more than 1900 degrees Celsius.

3. A spark plug according to claim 1 or 2 wherein the additive component of the iridium alloy is platinum or nickel.

4. A spark plug according to any preceding claim wherein at least one intermediate tubular layer (11) is provided between the tubular tip (10) and the inner core (9), the intermediate tubular layer (11) being made of metallic material, and having a thickness of more than 50 µm, and a coefficient of linear thermal expansion between that of the inner core and that of the tubular tip.

5. A spark plug according to claim 4, wherein the coefficient of linear thermal expansion of the intermediate tubular layer (11) is adapted to gradually increase in a direction from the inner core (9) to the tubular clad tip (10).

6. A spark plug according to any preceding claim wherein the axial length of the core (9) is greater than that of the tubular tip (10), so that a front end of the inner core (9) extends beyond that of the tubular clad tip (10).

7. An internal combustion engine comprises a spark plug according to any preceding claim.

Fig. 1

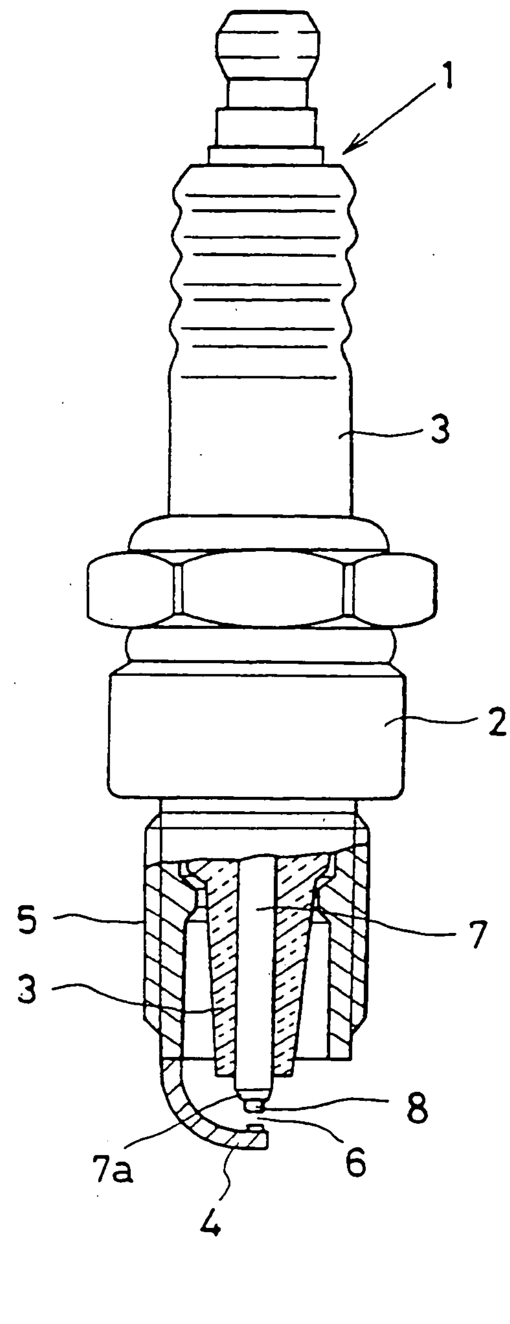


Fig. 2

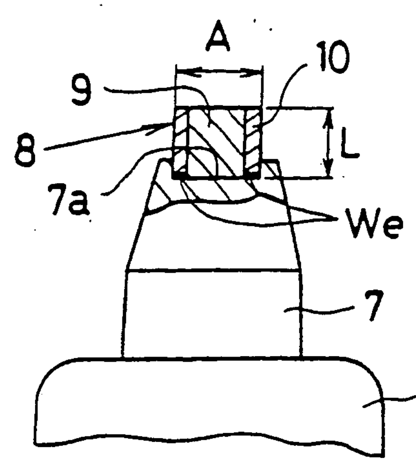



Fig. 3a

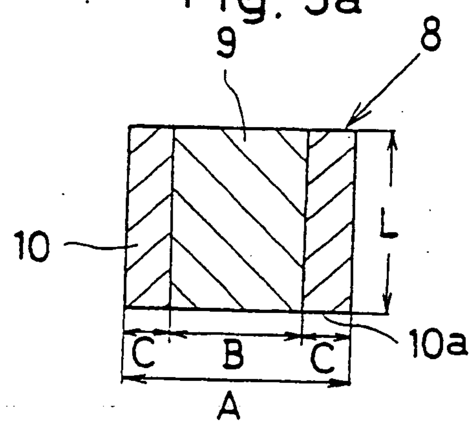



Fig. 3b

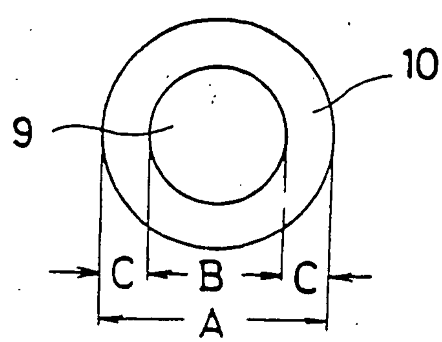



Fig. 4

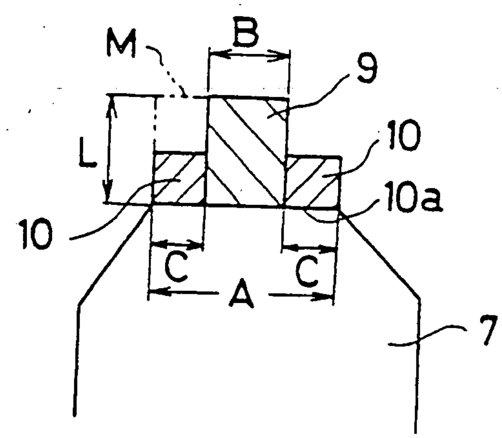


Fig. 5a

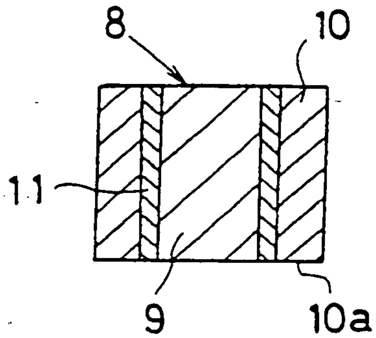



Fig. 5b

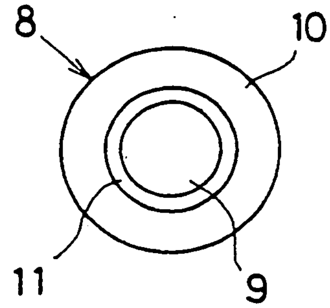
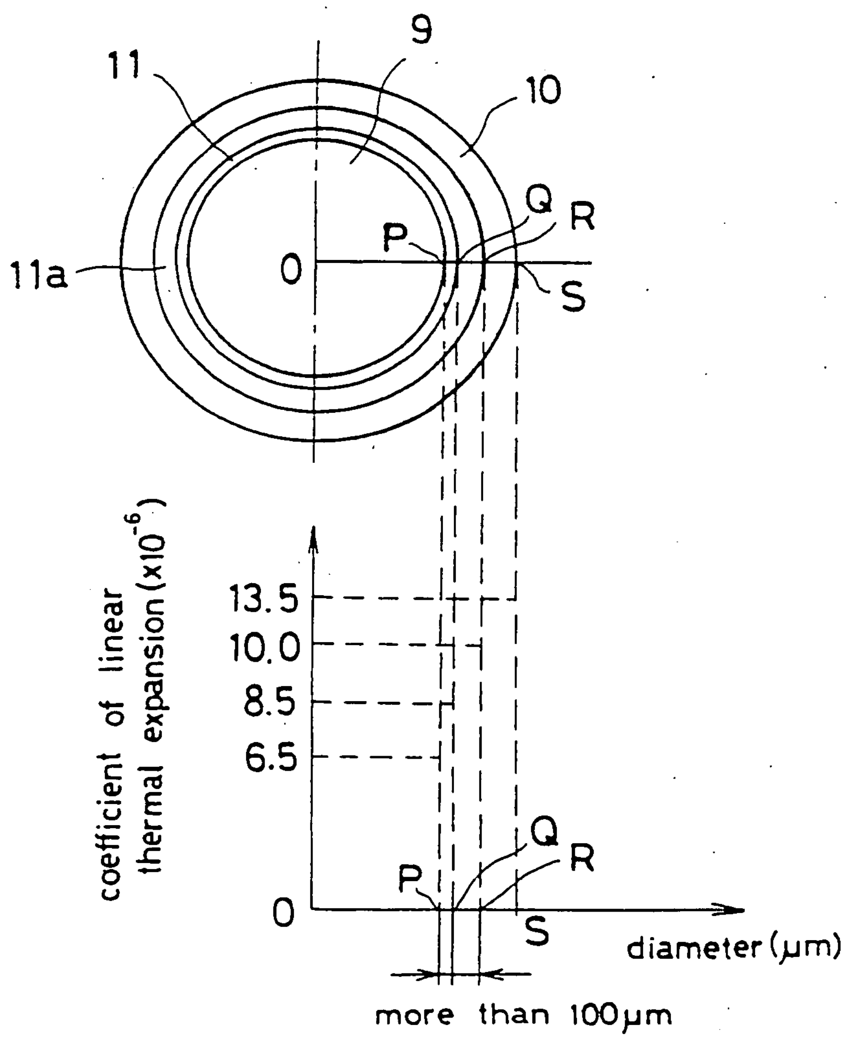



Fig . 6



European Patent Office

# EUROPEAN SEARCH REPORT

Application Number

EP 90 30 9980

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int. Cl.5) |
|---|---|---|---|
| A | FR-A-2552947 (RAU) * page 4, lines 23 - 33; figure * | 1. | H01T13/39 H01T21/02 |
| A | FR-A-866506 (GROOT-HANSEN) * page 1, line 57 - page 2, line 16; figures 1-3 * | 1. | |
| A | DE-A-3433683 (NGK SPARK PLUG) * page 8, line 8 - page 9, line 35; figures 1-4 * | 1, 2. | |
| A | US-A-3146370 (GEN. MOTORS CORP.) | | |

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

H01T

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| THE HAGUE | 24 OCTOBER 1990 | BIJN E.A. |

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document